United States Patent

[11] 3,584,161

[72] Inventor Melville S. Hawley
Indianapolis, Ind.
[21] Appl. No 781,854
[22] Filed Dec. 6, 1968
[45] Patented June 8, 1971
[73] Assignee Bell Telephone Laboratories, Incorporated
Murray Hill, Berkeley Heights, N.J.

[54] **BALANCED MAGNETIC TRANSDUCER**
9 Claims, 3 Drawing Figs.

[52] U.S. Cl. 179/119R
[51] Int. Cl. H04r 13/02
[50] Field of Search .... 179/114, 115, 117, 119, 179, 181, 114 R, 115 R, 119 R; 335/231

[56] **References Cited**

UNITED STATES PATENTS

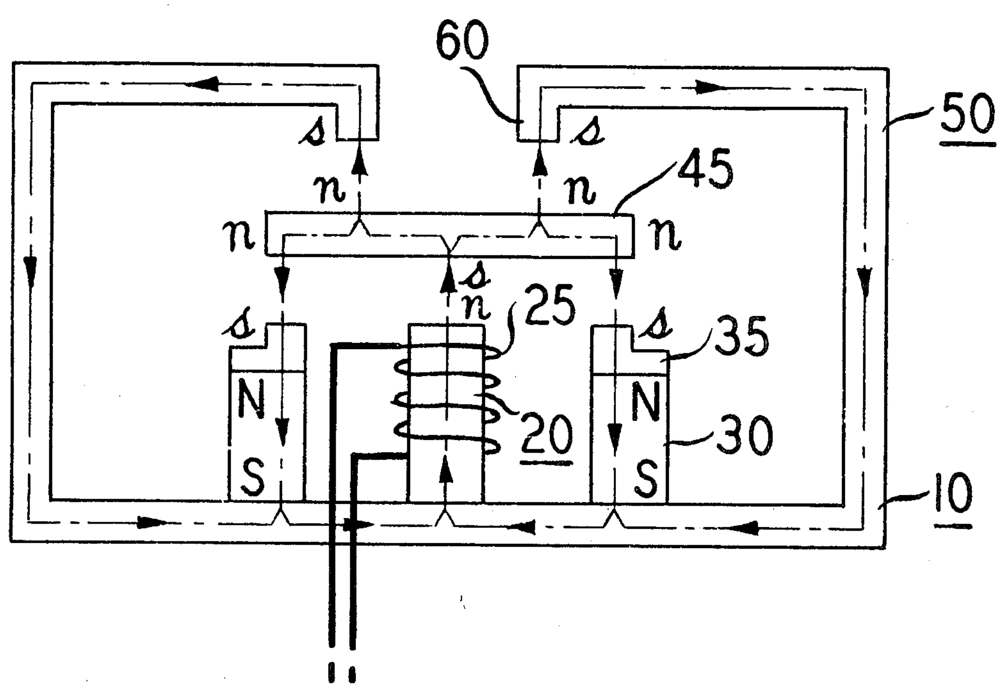
2,493,734 1/1950 Pearson 179/114
3,324,253 6/1967 Uemura et al. 179/117

FOREIGN PATENTS

166,259 2/1959 Sweden 179/114

Primary Examiner—William C. Cooper
Assistant Examiner—Thomas L. Kundert
Attorneys—R. J. Guenther and Edwin B. Cave

ABSTRACT: The transducer includes a cup-shaped magnetic enclosure having a center pole piece threaded into the base thereof. A coil is disposed about the pole piece and an annular permanent magnet encircles the coil, the magnet being in engagement with the base but spaced from the wall of the enclosure. An annular pole piece is mounted on the magnet and a magnetic armature overlies both the center and magnet pole pieces, a nonmagnetic support locating the armature in close proximity with the pole pieces and spaced from the wall of the enclosure. An annular balancing pole piece secured to the wall of the enclosure extends into close proximity with the upper surface of the armature to complete the magnetic circuit.



PATENTED JUN 8 1971

3,584,161

FIG. 1

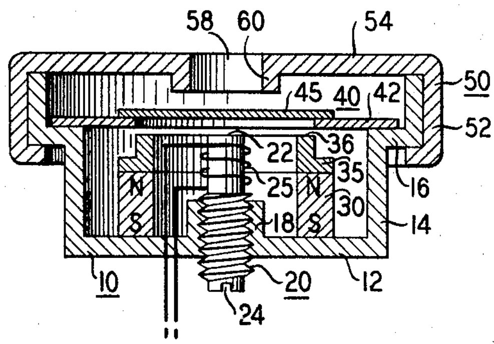


FIG. 2

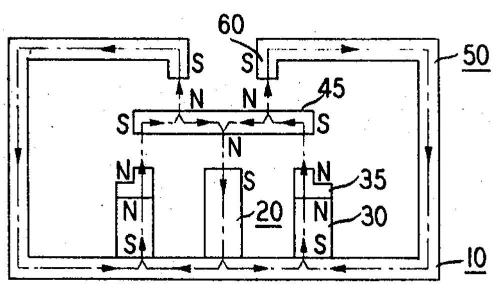
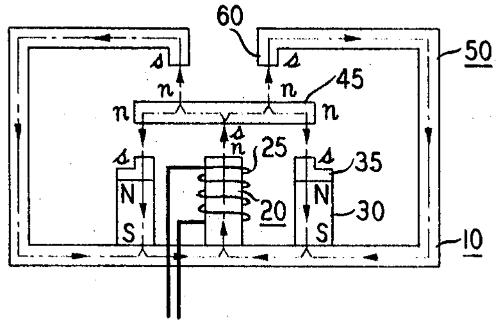


FIG. 3



INVENTOR
M. S. HAWLEY
BY Harry C. Newman
ATTORNEY

BALANCED MAGNETIC TRANSDUCER

FIELD OF THE INVENTION

This invention relates to the field of communications and within that field to electroacoustic transducers for converting sound waves into electrical signals wherein the transducers serve as transmitters, and for converting the electrical signals into sound waves wherein the transducers serve as receivers.

DISCUSSION OF THE PRIOR ART

As indicated in U.S. Pat. No. 2,360,796 issued to J. S. P. Roberton on Oct. 17, 1944, it is recognized in the electroacoustic transducer art that there are several advantages to a balanced armature system, a balanced armature system being one in which two criteria are met. First, the armature is positioned between oppositely magnetized poles, and the polarizing flux passing through the airgaps on each side of the armature acts upon the armature with equal force. Second, the magnetic circuit is such that when the signal flux aids the polarizing flux in the airgaps on one side of the armature, it opposes the polarizing flux in the airgaps on the other side of the armature. Since the pull on one side of the armature increases at the same time that the pull on the other side of the armature decreases, the balanced armature system provides both very high efficiency and reduced distortion due to harmonics.

However, a balanced armature system also has some disadvantages. As exemplified by the aforementioned patent, in many balanced armature systems the armature serves as the diaphragm or is part of the diaphragm of the electroacoustic transducer, and then the diaphragm must be clamped at its periphery. Otherwise it is unstable because of the equal magnetic forces acting to deflect it in opposite directions. Clamped diaphragms, though, tend to distort after repeated expansions and contractions due to normal temperature fluctuations. This distortion results in a displacement of the armature from its balanced position and therefore adversely affects the response of the transducer.

In addition, as also exemplified by the aforementioned patent, balanced armature systems are more complex than unbalanced systems in that they have several permanent magnets and/or several coils and/or a linkage between the armature and the diaphragm. Furthermore, they have to be accurately formed and assembled to provide the desired balance. All of these factors result in balanced armature systems being more expensive than unbalanced systems.

SUMMARY OF THE INVENTION

An electroacoustic transducer is herein disclosed that has a pseudobalanced armature structure so that it approaches the high efficiency of such a structure but at the same time does not have the mechanical instability and the high cost of fabrication of the true balanced armature structure. Specifically, the electroacoustic transducer herein disclosed has the characteristics of a balanced armature system except that the force exerted by the polarizing flux in the airgaps on one side of the armature does not equal the force exerted by the polarizing flux in the airgaps on the other side of the armature. This arrangement does not have as high an efficiency or reduce harmonics to as great a degree as in a completely balanced armature system, but it does permit the use of an unclamped diaphragm and it does allow for a simpler and less expensive structure.

Thus the electroacoustic transducer of the present invention comprises a permanent magnet and two pole pieces positioned on one side of the armature and a balancing pole piece positioned on the other side of the armature. Each of the pole pieces is magnetically connected to an individual pole of the permanent magnet, the two pole pieces on the one side being magnetically connected to different poles of the permanent magnet. In addition, one of these two pole pieces has a coil disposed thereabout, and it is connected to the same pole of the permanent magnet as the balancing pole piece.

With this arrangement the pole pieces exert a magnetic attraction on both sides of the armature, but there is a greater force exerted by the two pole pieces on the one side than the balancing pole piece exerts on the other side. The difference between the two forces maintains the armature in position. Furthermore, with this arrangement the flux paths are such that the signal flux aids the polarizing flux on one side of the armature and opposes the polarizing flux on the other side of the armature.

DESCRIPTION OF THE DRAWING

FIG. 1 is a cross-sectional view of an embodiment of the electroacoustic transducer of this invention;

FIG. 2 is a schematic view of the electroacoustic transducer of FIG. 1 showing the polarizing flux paths; and

FIG. 3 is a schematic view of the electroacoustic transducer of FIG. 1 showing the signal flux paths.

DETAILED DESCRIPTION

Referring to FIG. 1 of the drawing, the electroacoustic transducer of this invention includes a cylindrical cup-shaped support member **10** formed from a soft magnetic material, the support member **10** having a base portion **12** and a wall portion **14**. The wall portion **14** has a step therein to provide a shoulder **16**, and the base portion **12** has a centrally located cylindrical hub **18** that is threaded internally to accommodate a center pole piece **20**.

The center pole piece **20** is a cylindrical member that is externally threaded along the lower portion of its length. The upper end of the center pole piece **20** is provided with a pole face **22** while the lower end is provided with a slot **24**, the slot being engageable by a screwdriver to adjust the position of the center pole piece within the hub **18**.

A coil **25** is disposed about the center pole piece **20**, the coil being wound on a spool (not shown), and an annular permanent magnet **30** encircles the coil. The permanent magnet **30** is coaxial with the center pole piece **20**, and the permanent magnet is magnetized axially so that one pole is at its upper end and the other pole is at its lower end. The permanent magnet **30** is mounted with its lower end, which in this case is the south pole, in engagement with the base portion **12** of the support member **10** while the upper end of the permanent magnet, which in this case is the north pole, has an annular pole piece **35** mounted thereon.

The pole piece **35**, which is L-shaped in axial cross section, serves to concentrate the polarizing flux flowing from the upper end of the permanent magnet **30** and is therefore properly referred to as the magnet pole piece. The magnet pole piece **35** has a pole face **36** that is advantageously located in approximately the same plane as the pole face **22** of the center pole piece **20**, and both the permanent magnet **30** and the magnet pole piece are spaced from the wall portion **14** of the support member **10** so that little flux leakage occurs between the sides thereof and the wall portion.

A diaphragm assembly **40** is positioned on the shoulder **16** of the wall portion **14**, the diaphragm assembly comprising a diaphragm **42** and an armature **45**. The diaphragm **42** is a flat nonmagnetic disc of a diameter slightly less than the inside diameter of the upper end of the wall portion **14**, and the diaphragm has a central opening therein. The armature **45** is a flat, soft magnetic disc of greater diameter than the central opening in the diaphragm **42** and the armature is bonded to the upper surface of the diaphragm concentric with the opening therein. The elements of the electroacoustic transducer are so shaped and sized that the diaphragm **42** supports the armature **45** in close proximity with the pole faces **22** and **36** of the center and magnet pole pieces **20** and **35** but substantially spaced from the wall portion **14** of the support member **10**.

The electroacoustic transducer structure is completed by an inverted cylindrical cup-shaped cover member **50** having a wall portion **52** and a top portion **54**. The wall portion **52** is of a diameter to be telescoped over the wall portion **14** of the support member **10** and is of a length to be swaged over the shoulder **16** of the wall portion **14** to join the cover member **50** to the support member. The top portion **54** of the cover member **50** has a hole **58** therein and circumscribing the hole is a pole piece **60** that extends downward into close proximity with the armature **45**. The hole **58** permits acoustical energy generated by the diaphragm assembly **40** to be transmitted external to the transducer when the transducer is used as a receiver and permits acoustical energy generated external to the transducer to impinge upon the diaphragm assembly when the transducer is used as a transmitter.

The cover member **50**, like the support member **10**, is formed from a soft magnetic material, and thus with the cover member joined to the support member the pole piece **60** is magnetically connected to the permanent magnet **30**. The term "magnetically connected" as used in the specification and in the claims means joined by an essentially continuous ferromagnetic path. Furthermore, the cover member **50** and the support member **10** combine to form a magnetic enclosure that shields the transducer from stray magnetic flux external thereto and prevents the magnetic flux generated by the transducer from interfering with components adjacent thereto.

Referring now to FIG. **2**, with the foregoing structure the polarizing flux generated by the permanent magnet **30** flows from the north pole of the permanent magnet through the magnet pole piece **35**, through the airgap between the magnet pole piece and the armature **45**, and into the armature. At this point, the polarizing flux divides, part of the polarizing flux flows longitudinally through the armature **45** to its center, through the airgap between the armature and the center pole piece **20**, through the center pole piece, and then through the support member **10** to the south pole of the permanent magnet **30**. The other portion of the polarizing flux flows transversely through the armature **45**, through the airgap between the armature and the pole piece **60**, and then through the cover and support members **50** and **10** to the south pole of the permanent magnet. These two polarizing flux paths produce permanent polarities at the gaps as shown with capital letters in FIG. **2**.

As a result of these two polarizing flux paths the center pole piece **20** and the magnet pole piece **35** exert a downward force on the armature **45**, while the pole piece **60** exerts an upward force on the armature. Since the upward force exerted by the pole piece **60** acts to balance the downward force of the center and magnet pole pieces **20** and **35**, the pole piece **60** is properly referred to as a balancing pole piece. However, the upward force exerted by the balancing pole piece **60** is not as great as the downward force exerted by the center and magnet pole pieces **20** and **35**, and this difference in magnetic force maintains the armature assembly **40** (FIG. **1**) seated on the shoulder **16** of the support member **10**.

Turning now to FIG. **3**, signal flux generated by the coil **25** when the transducer is used as a receiver and by the movement of the armature **45** when the transducer is used as a transmitter flows through similar flux paths. The electrical signal flowing through the coil **25** or the acoustical signal impinging upon the armature **45** is of course an alternating one and consequently the signal flux is constantly reversing direction. During some portions of the signal, the signal flux flows from the upper end of the center pole piece **25**, through the airgap between the center pole piece and the armature **45**, and into the armature where it divides. One part of the signal flux flows longitudinally out from the center of the armature **45**, through the airgap between the armature and magnet pole piece **35**, through the magnet pole piece and the permanent magnet **30**, and through the support member **10** back to the center pole piece **20**. The other part of the signal flux flows transversely through the armature **45**, through the airgap between the armature and the balancing pole piece **60**, and through the cover and support members **50** and **10** back to the center pole piece **20**. During the other portions of the signal, the signal flux flows in the opposite direction.

The signal flux flow during the first of the above-mentioned portions of the signal produces signal polarities at the gaps as shown with small letters in FIG. **3**. As seen by comparing the signal polarities with the permanent polarities in FIG. **2**, the signal flux aids the polarizing flux in the gap between the armature **45** and the balancing pole piece **60**, but opposes the polarizing flux in the gaps between the armature and the center pole piece **20** and between the armature and the magnet pole piece **35**. Thus the upward pull on the armature **45** increases while the downward pull decreases, and both changes act to deflect the armature upward.

When the signal flux reverses direction, the signal polarities reverse and then the signal flux aids the polarizing flux in the airgaps between the armature **45** and the center and magnet pole pieces **20** and **35** and opposes the polarizing flux in the airgap between the armature and the balancing pole piece **60**. As a result, the downward pull on the armature **45** increases while the upward pull decreases, and both changes act to deflect the armature downward. The deflection of the armature whether up or down is of course proportional to the strength of the signal.

It is to be noted that with the present arrangement only a portion of the signal flux must flow through the permanent magnet **30**. A permanent magnet has a high AC reluctance, and it therefore attenuates the signal flux. Thus by providing a signal flux path that shunts the permanent magnet **30**, the efficiency of the electroacoustic transducer is increased.

Although a specific embodiment of the invention has been shown and described, it will be understood that it is but illustrative and that various modifications may be made therein without departing from the scope and spirit of this invention as defined in the appended claims.

What I claim is

1. An electroacoustic transducer comprising:

an armature of magnetic material;

a permanent magnet for generating a polarizing flux;

a first major polarizing flux path including a first pole piece extending adjacent to one side of the armature and magnetically connected to a first pole of the permanent magnet, an airgap between the first pole piece and the armature, and a longitudinal portion of the armature; and

a second major polarizing flux path including a second pole piece extending adjacent to the other side of the armature and magnetically connected to the first pole of the permanent magnet, the second magnetic flux path shunting the airgap and the pole piece of the first magnetic path.

2. An electroacoustic transducer as in claim **1** further including a third pole piece extending adjacent to the armature and magnetically connected to the second pole of the permanent magnet, the third pole piece being positioned between the permanent magnet and the armature, the third pole piece further being included in both the first and second major polarizing flux paths and directing the majority of the polarizing flux in a single flux path to the armature.

3. An electroacoustic transducer as in claims l, or 2 wherein the magnet magnetic connection between the second pole piece and the permanent magnet in combination with the magnetic connection between the first pole piece and the permanent magnet provides a magnetic enclosure for the transducer and the armature is supported so that the major flux flow therethrough is directed to the magnetic enclosure only through the first and second pole pieces.

4. An electroacoustic transducer as in claim **1** wherein the magnetic connection between the second pole piece and the permanent magnet in combination with the magnetic connection between the first pole piece and the permanent magnet provides a magnetic enclosure for the transducer and a third pole piece magnetically connected to the second pole extends adjacent to the one side of the armature, the third pole piece being spaced from the magnetic enclosure so that little flux flow occurs from the third pole piece directly to the magnetic enclosure.

5. An electroacoustic transducer as in claims 1, 2 or 4 further including means for generating a signal flux associated with the first pole piece and further including a major signal flux path including the airgap between the first pole piece and the armature, a portion of the armature, an airgap between the armature and the second pole piece, and the second pole piece.

6. An electroacoustic transducer comprising:
a magnetic enclosure including a base, a wall upstanding from the base, and a top overlying the base;
a balancing pole piece depending from and magnetically connected to the top;
a center pole piece upstanding from and magnetically connected to the base;
a coil disposed about the center pole piece;
a permanent magnet positioned between the coil and the wall of the enclosure, the permanent magnet being spaced from the wall but magnetically connected to the base of the enclosure;
a magnetic armature; and
a nonmagnetic support for the armature, the support locating the armature intermediate and in close proximity with the balancing pole piece and the center pole piece, but the armature from the wall of the enclosure. **8c 0250**

7. An electroacoustic transducer as in claim 6 further including a third pole piece positioned on the permanent magnet, the third pole piece being spaced from the wall of the magnetic enclosure but extending into close proximity with the armature.

8. An electroacoustic transducer comprising:
an armature of magnetic material;
a permanent magnet for generating a polarizing flux;
a first polarizing flux path including a first pole piece extending adjacent to one side of the armature and magnetically connected to a first pole of the permanent magnet, an airgap between the first pole piece and the armature, and a longitudinal portion of the armature;
a second polarizing flux path including a second pole piece extending adjacent to the other side of the armature and magnetically connected to the first pole of the permanent magnet, the second magnetic flux path shunting the airgap and the pole piece of the first magnetic path; and
a third pole piece extending adjacent to the armature and magnetically connected to the second pole of the permanent magnet, the third pole piece being positioned between the permanent magnet and the armature and directing the polarizing flux in a single major flux path to the armature.

9. An electroacoustic transducer comprising:
an armature of magnetic material;
a permanent magnet for generating a polarizing flux;
a first polarizing flux path including a first pole piece extending adjacent to one side of the armature and magnetically connected to a first pole of the permanent magnet, an airgap between the first pole piece and the armature, and a longitudinal portion of the armature; and
a second polarizing flux path including a second pole piece extending adjacent to the other side of the armature and magnetically connected to the first pole of the permanent magnet, the second magnetic flux path shunting the airgap and the pole piece of the first magnetic path;
the magnetic connection between the second pole piece and the permanent magnet in combination with the magnetic connection between the first pole piece and the permanent magnet providing a magnetic enclosure for the transducer, and the armature being supported so that the major flux flow therethrough is directed to the magnetic enclosure only through the first and second pole pieces.